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940572 COMPLETE SPECIFICATION
 This drawing is a reproduction of
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 2 SHEETS
 Sheets 1 & 2

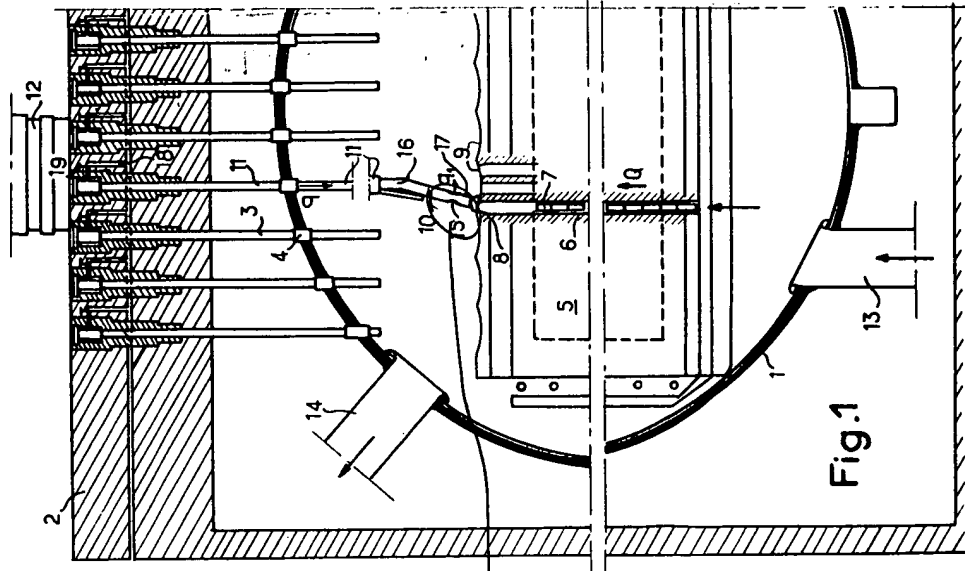


Fig.1

aperture in shaft
 permitting escape
 of fluid

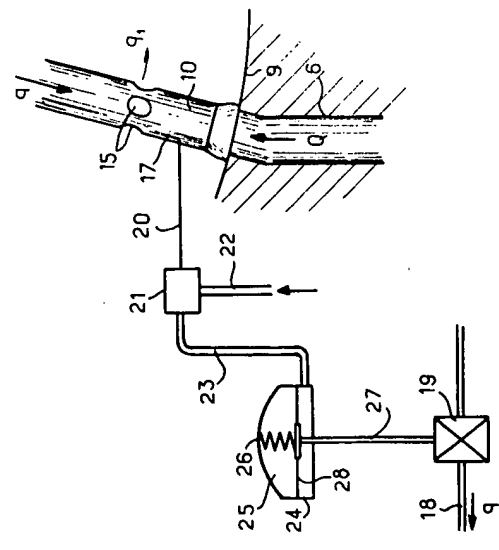


Fig.2

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PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Improvements in or relating to Nuclear Reactor Fuel Element Charging Arrangements

We, SOCIÉTÉ INDATOM, a limited liability Company organised under the laws of the French Republic, of 48 rue La Boetie, Paris 8, France, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed to be described in and by the following statement:—

The invention relates to heterogeneous nuclear reactors which are cooled by the circulation of fluid under pressure, and in which the elements of fissile material are arranged end-to-end in a number of channels provided inside the moderator core.

In such reactors, the operations of loading and unloading the elements of fissile material are generally carried out, in known manner, by means of gripping or guiding mechanisms, such as pincers or articulated arm which are introduced for this purpose into the pressurised vessel of the reactor, through fixed loading tubes which pass through said casing in a sealed manner.

In reactors of this type, which are cooled by the circulation of fluid under pressure in the various channels, the operations of handling the fuel elements may sometimes, unless special precautions are taken, give rise to displacement phenomena such as the "flight of the fuel elements" in reactors with vertical channels, or the phenomenon of advance (hereinafter also referred to as "flight") in reactors with horizontal channels.

Actually, if a nuclear reactor with vertical channels is considered, for the sake of argument, it will be seen that in a given channel, the uppermost fuel element is subjected to two vertical forces:

- a) its own weight P, which is directed downwards;
- b) the force p, which is directed upwards and which is due to the difference in the pres-

sures of the coolant fluid prevailing at each end of the element and to the frictional forces.

In these circumstances, an element cannot be stationary unless $P \gg p$. Of these two forces, the one P, depends only on the element whereas the other, p, depends in particular, on the flow of the cooling gas and hence on the number of elements in the channel. It will therefore be easily appreciated that, for a given number of elements, there is a critical flow in the channel above which the apparent weight of the uppermost element is directed upwards and at which the above-mentioned phenomenon of "flight" is observed which would lead to the element "floating" in the cooling gas if no remedy were applied, and it will be understood that when the phenomenon appears at the uppermost element it will then follow in each of the elements therebelow.

The object of the present invention is a device permitting the flight of the fuel elements of a nuclear reactor to be prevented and resolving, in a particularly simple manner, the difficulties referred to above.

According to the present invention there is provided a heterogeneous nuclear reactor cooled by circulation of fluid under pressure including a device for preventing the flight, during handling, of the fuel elements, characterised in that a movable loading arm adapted for telescopic slidable fluid tight engagement with a stationary loading tube projecting through the reactor vessel and for partially fluid tight abutting connection with the mouth of each channel in the reactor, comprises, at its downstream portion, on the one hand at least one lateral aperture permitting the escape of the fluid into said vessel and on the other hand a means for deriving the value of the flow in the channel, means, which is situated at the upstream portion of each loading tube

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5 permitting the injection, into said loading arm, of a counterflow of fluid adapted to regulate said main flow in the channel being unloaded and the value of said counterflow being dependent, at every moment, on the derived values of the main flow fed to a control device which regulates an admission valve for said counterflow in such a manner as to maintain the flow in the channel continually lower than that which will cause the flight of an element or elements in the channel.

10 The application of the device forming the subject of the invention necessitates knowing the flow at every moment in the channel in question. For this purpose, the loading arm comprises at its lower portion, according to the invention, a thermocouple or a flowmeter which consequently enables the temperature at every moment at the outlet from the channel which is being served. Since the magnitudes n (number of elements contained in the channel), Q (main flow of the gas in said channel) and θ_0 (exit temperature of the gas) are inter-related, it follows that, if a thermocouple is used, the measurement of θ_0 enables the main flow Q in the channel in question to be deduced since obviously the number n of the elements remaining in the channel is known. Consequently, it is sufficient to render the rate of flow q of the counterflow, which has to be injected into the loading arm, dependent, by means of any known type of control device, on the value Q , which is measured at every moment, to obtain an automatic regulation of said flow Q to a value lower than the critical flow.

35 The counterflow q , thus injected, likewise enables the cooling of the elements being handled to be effective, which is one of the advantages of the present invention. If a thermocouple is situated at the lower portion of the loading arm, the readings of each of the thermocouples permanently situated in the upstream portion of each channel of the reactor can easily be checked.

40 Referring to the accompanying diagrammatic drawings figures 1 and 2 show a non-limiting example of an embodiment of the device for preventing the flight of the fuel elements in a heterogeneous nuclear reactor cooled by the circulation of gas under pressure, which is in accordance with the invention.

55 Figure 1 is a diagrammatic view, in section, of a reactor with vertical channels.

Figure 2 is a diagram of the control device associated with the reactor of Figure 1.

60 Figure 1 shows, in vertical section, a portion of a reactor with vertical channels and a solid moderator, and cooled by CO_2 under pressure, showing the pressure vessel 1, the biological shield 2, and the loading tubes such as 3 which lead on the one hand to the upper

portion of the biological shield 2 and on the other hand to the interior of the pressure casing 1, after having passed through this at pressure-tight points such as at 4 with telescopic slidable fluid tight engagement. The active core mass 5 of the reactor comprises a large number of vertical channels formed in the moderator, only one of which, the channel 6, is illustrated in Figure 1.

70 At the top, the channel 6 leads, by means of a connecting tube 8, to a concave spherical surface 9 which is brushed by the lower end of a loading arm 10 introduced by means of a loading machine 12 into that loading tube indicated at 11, of the tubes 3 which serves the channel in question, the arm making telescopic slidable fluid tight engagement with the loading tube. The radial dimensions of the channels 6 together with the dimensions of the lower end of the loading arm 10, have been deliberately greatly exaggerated to enable the fuel elements 7 contained therein to be shown.

75 The circulation of the cooling fluid in the reactor takes place from the bottom upwards, the inlet being at 13 and the outlet at 14. In the assembly described, under normal operation, the pressure drop due to the loss of head during the passage through the various channels of the reactor is of the order of 1 Kg per cm^2 . The loading arm 10 comprises lateral apertures such as 15 having a total cross section s , which permit the evacuation of the gas blown in at the lower portion of the channel 6, which cross-section is calculated so as not to lead to a loss of head greater than a certain predetermined value. The sealing of the loading arm 10 to the end of the connecting tube 8 and that of the articulation point 16 of said arm are provided in such a manner as only to give rise to a leakage less than 10% in value in relation to the flow q_1 escaping through the apertures 15 of cross-section s in the loading arm 10.

100 In the example shown in Figures 1 and 2, a thermocouple 17 situated at the lower or downstream portion of the loading arm 10, measures the temperature of the cooling gas as it leaves the channel 6 and permits regulation, by means of a conventional control device illustrated in Figure 2, of the rate of flow q at which the gaseous counterflow is introduced by means of a pipeline 18 and a valve 19 leading into the upstream or upper end of a loading tube 11. The aforesaid control device functions to cause the automatic regulation of the flow Q in the channel 6 being unloaded and enables Q to be maintained at desired values lower than the critical value; Q could even be rendered zero if necessary.

105 Figure 2 shows the lower portion of the loading arm 10 equipped, along its inner wall, with the thermocouple 17 the readings of which, corresponding to values of flow Q of the cooling gas through the channel 6, 130

are transmitted along the electric line 20 to the pressure regulator 21. This regulator 21 is fed with air under pressure through the pipe 22 and delivers, into the pipeline 23, air at a pressure which is regulated to a value which is a function of the readings of the thermocouple 17, the adjustment of the transfer function of the regulator being effected empirically once and for all. The pipeline 23 leads into the lower compartment 24 of the valve head 25 comprising the spring 26, the valve stem 27 and the flexible diaphragm 28. The stem 27 controls the opening of the valve 19 which regulates the flow q of the counterflow injected, according to the invention, into the loading tube 11.

By way of non-limiting example, the case of Figures 1 and 2 relates to a reactor having an output of 200 MW cooled by the circulation of carbon dioxide gas under pressure. For an inlet pressure of 26 Kg/cm² and an outlet pressure of 25 Kg/cm², the temperatures at the inlet and the outlet of each channel are respectively 180° C and 330° C and the weight rate of flow per channel is about 2 Kg/second.

In these circumstances, and for fuel elements each weighing about 20 Kg, the rate of flow q of the gaseous counterflow varies from 4 to 8 Kg/second according to the number of fuel elements in the channel, the flight of which it is desired to prevent.

WHAT WE CLAIM IS:—

1. A heterogeneous nuclear reactor cooled by circulation of fluid under pressure including a device for preventing the flight, during handling, of the fuel elements, characterised in that a movable loading arm adapted for teles-

copic slidable fluid tight engagement with a stationary loading tube projecting through the reactor vessel and for partially fluid tight abutting connection with the mouth of each channel in the reactor, comprises, at its downstream portion, on the one hand at least one lateral aperture permitting the escape of the fluid into said vessel and on the other hand a means for deriving the value of the main flow in the channel means, which is situated at the upstream portion of each loading tube permitting the injection, into said loading arm, of a counterflow of fluid adapted to regulate said main flow in the channel being unloaded and the value of said counterflow being dependent, at every moment, on the derived values of the main flow fed to a control device which regulates an admission valve for said counterflow in such a manner as to maintain the flow in the channel continually lower than that which will cause the flight of an element or elements in the channel.

2. A reactor as claimed in Claim 1, wherein the means for measuring the main flow in the channel being unloaded is a thermocouple.

3. A reactor as claimed in Claim 1, wherein the means for measuring the main flow in the channel being unloaded is a flowmeter.

4. A reactor substantially as described with reference to the accompanying drawings.

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